Science Unit:	***Physics Ideas***
Lesson 2:	***Forces of Nature***

School year:	2006/2007
Developed for:	Tecumseh Elementary School, Vancouver School District
Developed by:	Paul Nagelkerke (scientist), Marie Chomyn and Fern Louie (teachers)
Grade level:	Presented to grades 6-7; appropriate for Grades 6-7 with appropriate modifications.
Duration of lesson:	1 hour and 20 minutes
Notes:	These activities are likely to take longer than the estimated duration. Originally they were set up in a station approach with an instructor. Students continued to work on science activities during the week following the lesson.

Objectives

1. Understanding common non-contact forces: gravity, magnetism.
2. Understanding common contact forces: friction, elastic
3. Understanding the characteristics of forces: distance effects, shielding, force interactions.
4. Can you ever escape gravity? What happens in free fall? How do you move in zero gravity?

Background Information

We take gravity for granted: it has always been there. Yet gravity is the weakest of four atomic forces.

There are four atomic forces: strong nuclear, electromagnetic, weak nuclear, and gravity. They are listed in order of their strength.

The strong nuclear force keeps the protons in an atomic nucleus together, overcoming their electric repulsion of each other. The strong nuclear force has an extremely short range; the diameter of an atomic nucleus. Huge amounts of energy can be released when light atoms combine or fuse to create larger, heavier atoms. A nuclear 'fusion' bomb uses this principle to release energy. A nuclear bomb uses an atomic bomb to get it started, getting the fusion fuel hot enough for atomic nuclei to combine, the fusion of nuclei releases massive amounts of energy. Atoms are normally so stable that we do not have to worry about these types of atomic reactions happening spontaneously.

Electromagnetic force acts between charged clouds of electrons (negative charge) or protons (positive charge): similar charges repel each other, opposites attract. When charged particles move, they create a magnetic field, and similarly a magnetic field causes charged particles to move. The electromagnetic force acts over infinite distances, but the magnitude of the force diminishes in proportion to the square of the distance. Magnetic fields diminish over very short distances: magnets don't just jump across the room to stick to the fridge; they have to be within a few cm of a metal surface to be strongly attracted.

The weak atomic force is responsible for holding together larger nuclei, such as those found in heavy elements. The range of the weak atomic force is extremely small, much smaller than the diameter of a proton. In heavy unstable elements such as Plutonium-238, the weak nuclear force is only just able to hold the nucleus together: the nucleus regularly splits spontaneously (nuclear decay), but can also be triggered by other nearby nuclei splitting, a chain-reaction. A chain reaction can be triggered in unstable Uranium or Plutonium atoms by reaching a certain density of atoms (critical mass). At this point the heavy atoms split, releasing two or more lighter atoms, and a number of elemental particles (protons, neutrons, electrons, photons) that trigger other atoms to split, etc.

Gravity is the weakest atomic force, but is responsible for the formation of the entire universe. Every atomic particle exerts a minute gravitational attractive force on every other atomic particle in existence. The force is extremely weak, acts over infinite distances, but the magnitude of the force diminishes in proportion to the square of the distance. The force is so weak you only notice it when you are close to extremely large masses, on the order of a 12,000 km diameter rock (such as the Earth).

Gravity gradually tapers off as you leave the planet, but we can't feel the difference. If gravity is at 100% at sea level, on the top of Mount Everest (8850 m) the force of gravity is 99.7% that found at sea level. At an altitude of 100 km, where the Space Shuttle orbits, gravity is 96.9% that on the surface. At geosynchronous orbit where communication satellites orbit once a day (36,000 km), gravity is only 2.2%, and out by the orbit of the Moon (384,000 km) gravity is only 0.02% that felt on the surface of the Earth.

Vocabulary

<u>Force</u>	An influence that may cause a body to accelerate
<u>Acceleration</u>	Changes in the velocity of an object
<u>Gravity</u>	An invisible attractive force exerted by all objects, proportional to mass and distance
<u>Elastic</u>	A body that can repeatedly deform and return to its original shape
<u>Friction</u>	The forces felt when two objects contact each other
<u>Magnetic Field</u>	An invisible force exerted by some objects.

Materials

- Rubber bands
- Hockey puck
- Rubber balls (different sizes)
- Bathroom scale
- Samples of Lodestone: natural magnets
- Magnets of different shapes: bar, disk, horseshoe, fridge magnetic sheet.
- Ferrous and non-ferrous (non-magnetic) objects such as washers, ball bearings, etc.
- Spherical magnets and matching ball bearings
- Ferro-magnetic liquid or magnetic viewer sheet

In the Classroom

Introductory Discussion

1. Gravity
    1. Earth exerts gravity on you, you exert gravity on the Earth. How many times more gravity does the Earth exert than you?
    2. How does the range of a magnetic field compare to a gravitational field?
    3. What other forces act on objects in a room besides gravity? (think about a feather).

2. Short description of other items to discuss or review:
    - Does the Space Shuttle really experience zero gravity? (what is micro-gravity?)

3. Summary of instructions for science experiment/activity.
    - Measure heights to the nearest millimeter.

4. Briefly describe safety guidelines.
    - Don't throw objects at anybody.
    - Very Important: Keep the magnets away from computers, electronics, and credit cards!
    - Very Important: Do not place magnets near nose, ears, or mouth. Swallowing magnets can kill you! (how?)

Science Activity/Experiment

Stations are set up in the classroom. One or two adults can run the entire class.

Divide the students into three or four equal groups. Save some time at the end of each station time to discuss the student observations.

1. Prisoners of Gravity
    a. Using the bathroom scale, measure your weight (mass) at three different distances from the center of the Earth. Hint: use distances of about 0, 3, and 6 metres. Can you measure any differences over these distances? Record your elevations and weights.
    b. Drop a large and small rubber ball at the same time; do they hit the floor at the same time? Drop a small rubber ball and piece of paper: do they hit the ground at the same time? Crumple the paper into a small ball, and drop them again. Did they hit the ground at the same time? What changes when you crumple up the sheet of paper? Record your observations.
    c. Drop a large rubber ball, a small rubber ball, and a hockey puck from the same height; which bounces higher? Calculate the efficiency of each object as a percentage of the drop and bounce heights in your notebook.

2. Magnetic Personality
    a. What does a magnetic field look like? Use the magnetic field viewer to look at bar magnets, horseshoe magnets, disk magnets, and a magnetic sheet (fridge magnet). Draw a picture of each field in your notebook.
    b. What does the magnetic field look like for attracting and repelling magnets? Draw a picture in your notebook.
    c. Separate the spherical magnets and ball-bearings. How can you tell the difference between them? How many ball-bearings can you lift with one magnet, with two

magnets? What is the best arrangement of magnets and ball-bearings to lift the most ball bearings? Record your observations in your notebook.

Science Journal: Students will record their observations and calculations.

Closure Discussion

Examples of questions to ask students.

1. Does gravity act over long distances?
2. Do magnetic fields work over long distances?
3. Can lunar gravity affect you? Do other planet's gravity affect you? Compare to the gravity influence of the person next to you. What does this say about Astrology?
4. Compare the force of gravity between a 100 kg person and the Earth (981 Newtons) and two 100 kg people standing 0.5 metres apart (2.6×10^{-6} Newtons or 0.000 002 6 Newtons) a difference of 50 million times.

References

1. www.Wikepedia.com/wiki/moon - Moon facts
2. www.Factmonster.com - height of Mount Everest

Extension of Lesson Plan

1. Display the effect of gravity with a torsion balance setup: "Bending Spacetime in the Basement" http://www.fourmilab.ch/gravitation/foobar/